General

Guideline Title

ACR Appropriateness Criteria® plexopathy.

Bibliographic Source(s)

Wippold FJ II, Cornelius RS, Aiken AH, Angevine PD, Angtuaco EJ, Brown DC, Fries IB, Holly L, McConnell CT Jr, Mechtler LL, Roth CJ, Seidenwurm DJ, Waxman AD, Winfree CJ, Expert Panel on Neurologic Imaging. ACR Appropriateness CriteriaÂ® plexopathy. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 14 p. [57 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Wippold FJ II, Miller-Thomas MM, Cornelius RS, Angevine PD, Broderick DF, Brown DC, Brunberg JA, Davis PC, De La Paz RL, Fries IB, Garvin CF, Hartl R, Holly L, McConnell CT Jr, Mukherji SK, Seidenwurm DJ, Sloan MA, Smirniotopoulos JG, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® plexopathy. [online publication]. Reston (VA): American College of Radiology (ACR); 2009. 9 p.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Plexopathy

Variant 1: Brachial—acute onset or chronic plexopathy without trauma.

Radiologic Procedure	Rating	Comments	RRL*
MRI neck without and with contrast	8	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI neck without and with contrast	7,8,9 Usually appropriate	Examination should include upper chest and proximal upper extremity. One or more additional anatomically	O

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation

Radiologic Procedure	Rating	Comments	RRL*
		contiguous studies may be appropriate depending on clinical circumstances.	
CT neck with contrast	5	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without contrast	4	Examination should include upper chest and proximal upper extremity. One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without and with contrast	3	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
X-ray chest	3		
X-ray cervical spine	3		
FDG-PET/CT whole body	1	May be valuable in patients with breast cancer in whom MRI or CT is nondiagnostic.	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Brachial—plexopathy due to traumatic injury.

Radiologic Procedure	Rating	Comments	RRL*
MRI neck without and with contrast	8	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI neck without contrast	7	Examination should include upper chest and proximal upper extremity. One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	O
Myelography and post myelography CT cervical and thoracic spine	6		
CT neck with contrast	5	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	

Radiologic Procedure	Rating	Comments	RRL*
Radiologic Procedure: cervical and thoracic spine	Rating	Comments	RRL*
CT neck without contrast	4	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without and with contrast	3	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
X-ray chest	3		
X-ray cervical spine	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Brachial—entrapment syndromes.

Radiologic Procedure	Rating	Comments	RRL*
MRI neck without and with contrast	8	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI neck without contrast	7	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	O
CT neck with contrast	6	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without contrast	5	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without and with contrast	3	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
X-ray chest	3		
X-ray cervical spine	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation

Radiologic Procedure	Rating	Comments	RRL*
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Brachial—post-treatment syndrome.

Radiologic Procedure	Rating	Comments	RRL*
MRI neck without and with contrast	8	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI neck without contrast	7	Examination should include upper chest and proximal upper extremity. One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.	O
FDG-PET/CT whole body	7		
CT neck with contrast	5	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without contrast	4	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT neck without and with contrast	3	Examination should include upper chest and proximal upper extremity. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	
X-ray chest	3		
X-ray cervical spine	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Lumbosacral—acute onset or chronic plexopathy without trauma.

Radiologic Procedure	Rating	Comments	RRL*
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative

Radiologic Procedure	Rating	Comments	RRL*
MRI pelvis without and with contrast	8	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI pelvis without contrast	7	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	O
CT pelvis with contrast	5	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without contrast	4	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without and with contrast	3	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
X-ray lumbosacral spine	3		
FDG-PET/CT whole body	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Lumbosacral—plexopathy due to traumatic injury.

Radiologic Procedure	Rating	Comments	RRL*
MRI pelvis without and with contrast	8	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

MRI pelvis without and with contrast 8 Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions." O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate *Relative Radiation Level

Radiologic Procedure	Rating	Comments	RRL*
		anatomically contiguous studies may be appropriate depending on clinical circumstances.	
CT pelvis with contrast	5	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without contrast	4	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without and with contrast	3	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
X-ray lumbosacral spine	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Lumbosacral—entrapment syndromes.

Radiologic Procedure	Rating	Comments	RRL*
MRI pelvis without and with contrast	8	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI pelvis without contrast	7	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	O
CT pelvis with contrast	6	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without and with contrast	4	Examination should include lower abdomen and	*Relative

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

Radiologic Procedure	Rating	Comments	RRL*
		proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
X-ray lumbosacral spine	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Lumbosacral—post-treatment syndrome.

Radiologic Procedure	Rating	Comments	RRL*
MRI pelvis without and with contrast	8	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI pelvis without contrast	7	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances.	O
FDG-PET/CT whole body	7		
CT pelvis with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
CT pelvis without and with contrast	3	Examination should include lower abdomen and proximal lower extremities. One or more additional anatomically contiguous studies may be appropriate depending on clinical circumstances. Oral contrast often used.	
X-ray lumbosacral spine	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Plexopathy is the term used to describe abnormal neurological symptoms and signs localized to an anatomically defined network of nerves called a nerve plexus. Nerve plexuses are derived from the ventral rami of a set of spinal nerves. Commonly recognized nerve plexuses include the brachial plexus and the lumbosacral plexus. The brachial plexus is formed from C5-T1 ventral rami. The roots pass between the anterior and middle scalene muscles with the subclavian artery to form the trunks in the supraclavicular region. Trunks then split into anterior and posterior divisions, form cords, and travel with the subclavian artery and vein within the infraclavicular region. Finally, the cords form terminal branches at the lateral margin of the pectoralis minor muscle and continue through the axilla. Individual nerve branches then continue into the arm and forearm.

The lumbosacral plexus comprises two distinct plexuses, the lumbar and the sacral, with a bridging lumbosacral trunk. The lumbar plexus is formed from the L1-L3 ventral rami with contributions from T12 and L4. The roots emerge from the psoas major muscle, form anterior and posterior divisions, and finally form anterior and posterior branches. The lumbar plexus innervates the muscles of the anterior and medial thigh. The sacral plexus is formed from the L4-L5 ventral rami (the lumbosacral trunk) and S1-S4. Anterior and posterior divisions arise from the roots, course over the sacral promontory posterolateral to the internal iliac vessels, and terminate in branches innervating the muscles of the gluteal region, lateral and posterior thigh, and lower leg. The largest terminal branch, the sciatic nerve, exits the pelvis with the piriformis muscle and gluteal vessels through the greater sciatic foramen. Mastery of anatomy and availability of anatomical references are useful in interpreting studies of the brachial and lumbosacral plexus.

Plexopathy may manifest as pain (shoulder and arm or back and leg) with a neuropathic character, dysesthesia, and/or burning or electric sensation, occurring in more than one peripheral nerve distribution. In contradistinction, pain that radiates in a dermatomal distribution with or without accompanying sensory loss or motor loss in a spinal nerve root innervation would be considered clinical evidence of radiculopathy.

Complete brachial plexopathy causes weakness, sensory loss, and flaccid loss of tendon reflexes in body regions innervated by nerves in the C5-T1 segmental distribution. The clinical diagnosis is confirmed by electrodiagnostic studies (electromyography [EMG]) showing evidence of a neurogenic lesion in muscles innervated by at least two cervical segments involving at least two different peripheral nerves. Lumbar plexopathy produces weakness, sensory loss, and flaccid reflex changes in the distribution of spinal segments L2-L4, resulting in weakness and sensory loss in obturator- and femoral-innervated territories. Sacral plexopathy causes the same abnormalities in segments L5-S3, resulting in weakness and sensory loss in the gluteal (motor only), peroneal, and tibial nerve territories.

Imaging Modalities

Imaging attempts to visualize the plexus and surrounding structures. For brachial plexopathy, anatomic territories are targeted based on clinical findings and electrodiagnostic data but may include the cervical spine, chest, or shoulder. Generally, one side or the other is chosen for imaging, but imaging may be repeated for both sides as indicated by clinical findings. For lumbosacral plexopathy, imaging focuses on including both left and right sides of the lumbosacral plexus in a single field of view while maintaining a diagnostically appropriate spatial resolution. In general, cross-sectional imaging should be tailored to cover the pelvis and include the lumbar region to the L1 level.

Magnetic resonance imaging (MRI) at 1.5 Tesla (T) is the mainstay of plexus imaging, although imaging at 3T may offer some advantages. It has been shown to detect features of intraneural anatomy not previously seen with earlier diagnostic imaging studies and to localize pathologic lesions in conditions where electrophysiologic and physical findings are nonspecific or nonlocalizing.

The use of phased arrays and integrated arrays of radiofrequency (RF) coils for dedicated brachial plexus imaging directly evaluates the plexus components—roots, trunks, divisions, and cords — and may distinguish between intrinsic and extrinsic pathological changes. A 1994 study found conventional spin-echo MRI without gadolinium to be 63% sensitive, 100% specific, and 77% accurate compared to clinicopathologic results in the evaluation of 43 patients with suspected brachial plexopathy. Accuracy increased to 88% when evaluation involved only the subset of patients (n=34) with neoplastic or traumatic disorders. With current high-resolution MRI and the use of gadolinium contrast agents, accuracy is likely to be increased further.

T1-weighted images display regional anatomy, including muscles, blood vessels, and nerves, outlined by fat planes. Conventional two-dimensional (2D) fast spin-echo (FSE) sequences are used to generate the T1-weighted images, although some investigators prefer T1-weighted 3D gradient-echo images. The 2D T2-weighted images are generated with FSE sequences and are useful to detect pathologic changes within components of the plexus. Because abnormal intraneural signal from one component of the plexus, such as a root or a cord, may be obscured by adjacent fat signal, fat suppression is used. The two most common methods are short-tau inversion recovery (STIR) and frequency-selective saturation of the fat resonance. STIR may be especially useful in characterizing inflammatory conditions.

Contrast-enhanced images of the plexus are obtained routinely in patients being evaluated for suspected neoplasm, radiation injury, inflammation, or abscess formation, and following peripheral nerve surgery. In addition to these indications, contrast-enhanced images have also proven useful in some cases of nerve entrapment and stretch injury. In cases of acute severe traumatic nerve injury and simple compressive neuropathy, a noncontrast examination can be sufficient. High-resolution coronal and sagittal images of the symptomatic brachial plexus are especially beneficial. Axial images may be acquired in patients with a concomitant Horner's syndrome to demonstrate paraspinal extension of tumor. Three planes of images of the cervical spine are acquired when the clinical findings suggest an abnormality at the level of the cervical roots. For lumbosacral imaging, high-resolution coronal and axial images of the bilateral lumbar plexus or sacral plexus are typically obtained.

Optimization of MRI protocols for imaging the plexus has improved our ability to visualize the anatomy and detect pathology. Research continues to evaluate new techniques, such as diffusion-weighted imaging. As radiologists gain more experience with plexus imaging, imaging phenomena such as magic angle effect in plexus components oriented at 55 degrees to the magnetic field are being described. Magnetic resonance neurography, diffusion tensor imaging (DTI), and tractography are exciting developments currently under investigation.

Abnormal plexus findings include the following: atrophy of muscles innervated by the plexus, loss of fat planes around all or part of a plexus component, diffuse or focal enlargement of a component (especially the presence of an eccentric or nodular mass), marked hyperintensity on T2-weighted images, and/or enhancement on T1-weighted images with fat suppression. An altered fascicular pattern is also abnormal, although it may not always be apparent. Demonstration of a fascicular pattern may be more difficult for plexus components than for individual peripheral nerves, like the sciatic and tibial nerves, because of the lower spatial resolution of plexus images and because of the difficulty in obtaining true cross-sectional views of most plexus components.

Computed tomography (CT) imaging of the spine, chest, and body complements MRI of the plexus, especially in cancer patients. In patients unable to undergo MRI due to implanted devices, CT offers the next highest level of anatomic visualization possible for these patients.

Myelography and CT myelography outline the contours of the spinal cord and nerve roots with myelographic contrast injected via either a lumbar approach or a cervical approach. These techniques are complementary to MRI in the setting of trauma to evaluate the integrity of nerve roots and to localize secondary signs of nerve injury such as pseudomeningoceles.

Positron emission tomography (PET)/CT imaging performed with fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG) is beneficial in imaging patients with suspected malignancies directly invading or metastatic to the region of the plexus. As a problem-solving tool, it can be used to differentiate radiation plexitis from tumor recurrence in patients who have received radiation therapy to the region of the plexus.

Ultrasound (US) imaging of the brachial plexus is a new area of research both for diagnosis of plexopathies and for image-guided therapy. US is able to define the anatomy of the brachial plexus and demonstrate signs of trauma and tumor involvement. US of the brachial plexus is dependent on the skills of the technologist and is not yet in widespread use.

Indications for MRI of the Brachial Plexus

Acute Onset or Chronic Plexopathy without Trauma

Acute onset or chronic plexopathies may be caused by diverse etiologies such as intrinsic or extrinsic masses, radiation treatment, entrapment syndromes, and by miscellaneous causes such as infectious, autoimmune, hereditary, and idiopathic neuropathies. MRI of the plexus, aided by CT, CT myelography, and PET/CT as indicated, augment clinical findings and EMG studies in reaching a diagnosis and guiding treatment.

MRI can often determine whether a mass is intrinsic or extrinsic to a component nerve of the plexus and, for extrinsic masses, determine the site of the displaced and compressed nerve fibers prior to surgical intervention. Such information is valuable in the diagnosis and management of patients with plexopathy due to neoplastic or non-neoplastic processes. The information from MRI aids in preoperative planning and may help to shorten the surgical procedure. Primary tumors in organs adjacent to the plexus, such as lung, colon, and genitourinary tumors, may directly invade the plexus.

Lymphatic or hematogenous metastases to the structures surrounding the plexus have been reported with a wide variety of primary malignancies. Lymphoma can involve the plexus in two ways. First, enlarged lymph nodes can compress and/or infiltrate the plexus. Second, neurolymphomatosis, which is a rare manifestation of lymphoma primarily involving the peripheral nerves, can affect the plexus. Infiltrative lesions of the plexus include soft-tissue tumors such as sarcomas and fibromatosis. The most common neurogenic tumors of the plexus are the benign nerve sheath tumors such as neurofibroma and schwannoma. Malignant peripheral nerve sheath tumors account for 14% of the neurogenic tumors and occur more frequently in patients with neurofibromatosis or a history of radiation therapy. When the clinical examination does not reveal an etiology for the patient's neuropathy, MRI may identify a focal or diffuse peripheral nerve or plexus structural abnormality, such as occurs in chronic inflammatory demyelinating polyneuropathy (CIDP), multifocal motor neuropathy (MMN), hereditary hypertrophic motor and sensory neuropathies (HMSN), and inflammatory pseudotumor. Idiopathic brachial plexitis presents with sudden onset of severe, constant pain in the

lateral neck, shoulder, scapula, or upper arm. It may demonstrate increased signal intensity in the plexus on T2-weighted images, or the plexus may appear normal.

Plexopathy Due to Traumatic Injury

Traumatic injury to a peripheral nerve can range from disruption of axonal conduction with preservation of anatomical continuity of the connective tissue sheaths (neurapraxic injury) to avulsed or severed nerve with complete loss of continuity of the nerve (neurotmesis injury). By demonstrating the location and severity of injury and the morphology of the injured nerve, high-resolution MRI complements the electrophysiologic studies in determining the exact site and type of nerve injury and the potential for surgical treatment versus spontaneous recovery. Additionally, MRI may demonstrate the relationship of the intact nerve to post-traumatic lesions such as spindle, lateral, and stump neuromas, as well as focal or diffuse perineural fibrosis.

Intraspinal cervical nerve root avulsion (preganglionic lesion) should be distinguished from brachial plexus interruption (postganglionic lesion) because the surgical treatment differs. Somatosensory-evoked potentials have been routinely used to diagnose nerve root avulsion; however, because these do not enable one to discriminate between incomplete avulsion and intact roots, or between intraforaminal root avulsion and rootlet avulsion from the spinal cord, the inclusion of imaging studies (myelography, CT myelography, high-resolution MRI, and MR myelography) in the diagnostic evaluation has been recommended.

In the detection of nerve root avulsion, some studies found that myelography or CT myelography was the most accurate approach (>90%), confirming separate reports of the reliable demonstration of root avulsion with CT myelography and a 92% accuracy of MR myelography compared to CT myelography. Other studies, however, found that myelography/CT myelography and MRI achieved similar accuracy. In the detection of traumatic pseudomeningoceles, conventional spin-echo MRI is equivalent to CT myelography, which is more accurate than myelography. For overall characterization of traumatic brachial plexopathy, MRI has an advantage over CT and myelography, because it is better able to show plexus lesions (postganglionic), in addition to detecting pseudomeningoceles. Examples of post-traumatic lesions of the plexus that have been demonstrated on spin-echo images include neuromas (tangles of regenerating nerve fibers), focal or diffuse fibrosis, and masses that compress or stretch the plexus, such as hematoma, clavicular fracture, and humeral dislocation. In the region of the sacral plexus, multiplanar reconstructed CT slices may assist evaluation of sacral nerve injury due to sacral fracture.

Entrapment Syndromes

Guided to the location of entrapment/compression by the clinical and neurological examination, the MRI study is used to detect objective findings of nerve compression. There is some disagreement regarding the value of MRI in diagnosing neurologic or combined neurovascular thoracic outlet syndrome (TOS).

Post-treatment Evaluation

Patients with a history of cancer and clinical evidence of plexopathy following radiation therapy may have, predominantly or exclusively, recurrent tumor or radiation-induced plexopathy. Imaging features that favor recurrent tumor are nonuniform, diffuse, or focal enlargement of the plexus components and the presence of an eccentric mass with postcontrast enhancement. Imaging features that suggest postradiation injury of the brachial plexus are diffuse, uniform swelling and T2 hyperintensity of the plexus nerves within the radiation field. Diffuse, uniform postcontrast enhancement for months to years after treatment may also result from radiation injury. Radiation fibrosis often has low signal intensity on T1-weighted and T2-weighted images, and this may represent the more common appearance for chronic radiation injury, although a correlation between the time interval following radiation therapy and T2 signal intensity has not been reported.

Differentiation between radiation injury and local or regional recurrent cancer with axillary/supraclavicular metastases may not be possible. Preliminary results suggest that FDG-PET helps to confirm metastases in patients with indeterminate MRI findings and is useful for depicting metastases outside the axilla.

Summary

- Imaging of the plexus complements and supplements the clinical and electrophysiologic data in order to establish a diagnosis and assist treatment planning.
- MRI is the mainstay of imaging the brachial and lumbosacral plexus.
- MRI protocols should optimize visualization of the anatomy of the affected plexus and detection of pathologic conditions.
- CT, CT myelography, and PET/CT complement MRI in certain clinical settings.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from

limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Abbreviations

- CT, computed tomography
- FDG-PET, fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography
- MRI, magnetic resonance imaging

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
	<0.1 mSv	<0.03 mSv
	0.1-1 mSv	0.03-0.3 mSv
	1-10 mSv	0.3-3 mSv
	10-30 mSv	3-10 mSv
	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Plexopathy

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Family Practice

Internal Medicine

Neurology

Oncology

Radiology

Surgery

Intended Users

Health Plans

Hospitals

Managed Care Organizations

Physicians

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of initial radiologic examinations for patients with plexopathy

Target Population

Patients with plexopathy

Interventions and Practices Considered

1. Magnetic resonance imaging (MRI)
    - Neck without and with contrast
    - Neck without contrast
    - Pelvis without and with contrast
    - Pelvis without contrast
2. Computed tomography (CT)
    - Neck with contrast
    - Neck without contrast
    - Neck without and with contrast
    - Pelvis with contrast
    - Pelvis without contrast
    - Pelvis without and with contrast
3. X-ray
    - Chest
    - Cervical spine
    - Myelography cervical and thoracic spine
    - Lumbosacral spine
4. Fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET)/CT whole body
5. Myelography and post myelography CT cervical and thoracic spine

Major Outcomes Considered

Utility of radiologic examinations in differential diagnosis

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Procedure

The Medline literature search is based on keywords provided by the topic author. The two general classes of keywords are those related to the condition (e.g., ankle pain, fever) and those that describe the diagnostic or therapeutic intervention of interest (e.g., mammography, MRI).

The search terms and parameters are manipulated to produce the most relevant, current evidence to address the American College of Radiology Appropriateness Criteria (ACR AC) topic being reviewed or developed. Combining the clinical conditions and diagnostic modalities or therapeutic procedures narrows the search to be relevant to the topic. Exploding the term "diagnostic imaging" captures relevant results for diagnostic topics.

The following criteria/limits are used in the searches.

1. Articles that have abstracts available and are concerned with humans.
2. Restrict the search to the year prior to the last topic update or in some cases the author of the topic may specify which year range to use in the search. For new topics, the year range is restricted to the last 5 years unless the topic author provides other instructions.
3. May restrict the search to Adults only or Pediatrics only.
4. Articles consisting of only summaries or case reports are often excluded from final results.

The search strategy may be revised to improve the output as needed.

Number of Source Documents

The total number of source documents identified as the result of the literature search is not known.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Strength of Evidence Key

Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis, and results.

Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.

Category 3 - The conclusions of the study may be valid but the evidence supporting the conclusions is inconclusive or equivocal.

Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis.

Methods Used to Analyze the Evidence

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author drafts or revises the narrative text summarizing the evidence found in the literature. American College of Radiology (ACR) staff draft an evidence table based on the analysis of the selected literature. These tables rate the strength of the evidence for all articles included in the narrative text.

The expert panel reviews the narrative text, evidence table, and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the table. Each individual panel member forms his/her own opinion based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Modified Delphi Technique

The appropriateness ratings for each of the procedures included in the Appropriateness Criteria topics are determined using a modified Delphi methodology. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. American College of Radiology (ACR) staff distributes surveys to the panelists along with the evidence table and narrative. Each panelist interprets the available evidence and rates each procedure. The surveys are completed by panelists without consulting other panelists. The ratings are a scale between 1 and 9, which is further divided into three categories: 1, 2, or 3 is defined as "usually not appropriate"; 4, 5, or 6 is defined as "may be appropriate"; and 7, 8, or 9 is defined as "usually appropriate." Each panel member assigns one rating for each procedure per survey round. The surveys are collected and the results are tabulated, de-identified and redistributed after each round. A maximum of three rounds are conducted. The modified Delphi technique enables each panelist to express individual interpretations of the evidence and his or her expert opinion without excessive bias from fellow panelists in a simple, standardized and economical process.

Consensus among the panel members must be achieved to determine the final rating for each procedure. Consensus is defined as eighty percent (80%) agreement within a rating category. The final rating is determined by the median of all the ratings once consensus has been reached. Up to three rating rounds are conducted to achieve consensus.

If consensus is not reached, the panel is convened by conference call. The strengths and weaknesses of each imaging procedure that has not reached consensus are discussed and a final rating is proposed. If the panelists on the call agree, the rating is accepted as the panel's consensus. The document is circulated to all the panelists to make the final determination. If consensus cannot be reached on the call or when the document is circulated, "No consensus" appears in the rating column and the reasons for this decision are added to the comment sections.

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current literature and expert panel consensus.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of patients with plexopathy

Potential Harms

Gadolinium-based Contrast Agents

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Relative Radiation Level (RRL)

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate

decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Wippold FJ II, Cornelius RS, Aiken AH, Angevine PD, Angtuaco EJ, Brown DC, Fries IB, Holly L, McConnell CT Jr, Mechtler LL, Roth CJ, Seidenwurm DJ, Waxman AD, Winfree CJ, Expert Panel on Neurologic Imaging. ACR Appropriateness CriteriaÂ® plexopathy. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 14 p. [57 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2006 (revised 2012)

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

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Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Neurologic Imaging

Composition of Group That Authored the Guideline

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Wippold FJ II, Miller-Thomas MM, Cornelius RS, Angevine PD, Broderick DF, Brown DC, Brunberg JA, Davis PC, De La Paz RL, Fries IB, Garvin CF, Hartl R, Holly L, McConnell CT Jr, Mukherji SK, Seidenwurm DJ, Sloan MA, Smirniotopoulos JG, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® plexopathy. [online publication]. Reston (VA): American College of Radiology (ACR); 2009. 9 p.

Guideline Availability

Electronic copies: Available from the American College of Radiology (ACR) Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Evidence table development – diagnostic studies. Reston (VA): American College of Radiology; 2013 Nov. 3 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 90 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria® plexopathy. Evidence table. Reston (VA): American College of Radiology; 2012. 16 p. Electronic copies: Available from the ACR Web site.

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on April 25, 2007. This summary was updated by ECRI Institute on June 20, 2007 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents. This NGC summary was updated by ECRI Institute on May 26, 2010. This summary was updated by ECRI Institute on January 13, 2011 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents. This NGC summary was updated by ECRI Institute on October 12, 2012.

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